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Production of calabaza, Cucurbita moschata Duchesne, for direct market sale in Massachusetts using transplants, plastic mulch, and row cover /

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PRODUCTION OF CALABAZA, *CUCURBITA MOSCHATA* DUCHESNE, FOR DIRECT MARKET SALE IN MASSACHUSETTS USING TRANSPLANTS, PLASTIC MULCH, AND ROW COVER

A Thesis Presented

by

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CHAPTER 1

INTRODUCTION

Latinos are the fastest growing ethnic group in the Commonwealth. The 1997 Census for Massachusetts estimated that Spanish-speaking peoples, representing many diverse Latin American countries and cultures, represent 5% of the population (US Census, 1997). Latino populations are concentrated in the larger cities of Massachusetts and have the potential to represent a large proportion of the consumer base at farmers' markets, urban chain stores, and urban farm stands. Over the past few years, Latinos have addressed their interest in growing and purchasing vegetables native to their countries to members of the UMass Extension Vegetable and Small Fruit Team (F.X. Mangan, personal communication). After interviewing Latinos for food preferences, and searching the literature for suggested cultural practices, a collaborative project was initiated to identify a production research agenda for crops that have potential for being popular among Latino consumers and would be viable for production by local farmers. Due to a dominance of Puerto Ricans and Dominicans among Latinos in Massachusetts, the emphasis of the project was to grow crops specific to their respective cultures.

One crop was identified that showed potential for consumer interest and was unfamiliar to most vegetable growers in Massachusetts: calabaza, *Cucurbita moschata* Duchesne, a winter-type squash. Calabaza is the most important non-root crop consumed in Puerto Rico (Maynard and Elmstrom, 1993). Production practices applicable to the Northeast were unknown to Extension professionals and growers and therefore research was conducted to provide appropriate growing recommendations.

Literature Review

Calabaza

Calabaza is a pumpkin of tropical origin. Calabaza is a general term applied by Latinos to many distinct variations of *Cucurbita moschata* that are grown throughout the world. Classification as a *moschata* is primarily due to the pronounced flaring of the woody peduncle at the junction of the stem and fruit. Although referred to as a 'pumpkin' (*C. maxima*), calabaza shares more common traits with butternut-type winter squashes (*Cucurbita moschata* Duchesne) commonly grown throughout the United States.

Researchers in Florida conducted a market study to establish the consumer preferences of Caribbean Latinos for specific traits that would provide for a breeding strategy (Carbonnell et al., 1990). Traits identified as being the most important to consumers include flesh color, rind color, and size. To accommodate both consumer preferences and production interests, breeders in Florida have selected for deep yellow/orange flesh color, piebald green rind color, fruits that weigh an average of 4 to 7 kg, and plants that have a bush habit of growth. 'C42 ×La Segunda' is one calabaza hybrid that meets most preferred traits and has been developed by breeders for potential commercial production (Maynard, 1996). Seed of 'C42 ×La Segunda' was obtained from the University of Florida Gulf Coast Research and Extension Education Center and was the cultivar used for research trials at the UMass South Deerfield Agronomy Farm.

The primary concern for successful production of calabaza in the Massachusetts is the length of growing season. Most growers that serve farmer's markets visited by Latinos are interested in having calabaza ready for sale when markets are most active -

before Labor Day (F.X. Mangan, personal communication). According to production records in Florida and the Caribbean, calabaza requires 100 to 120 days from planting to reach maturity (Maynard and Elmstrom, 1993). To provide a mature crop for market by early September in Massachusetts using direct-seeding, it would need to be sown by the beginning of May. Damaging frosts can occur in Massachusetts through the end of May. Therefore, we propose to examine practices which will promote a marketable crop by the first week in September and provide adequate yields that will make the production of calabaza in Massachusetts a viable alternative for vegetable growers.

In regions where calabaza is commonly grown, length of season is not a limitation. Therefore, current research did not divulge any production guidelines that would be suitable for Northeastern climates. However, cultural practices used in growing other long season crops in cool climate areas may be applicable to growing calabaza in Massachusetts. Many practices have been utilized in Northern regions to grow cucurbits and other crops that are cold sensitive, including the use of transplants, plastic mulches, row covers, and combinations of the three.

Transplants

As early as 1929, transplants have provided for an earlier harvest, the development of better root systems, and the general ability to grow warm-season crops in regions too cold for direct-seeding (Watts, 1929; NeSmith 1999). Other advantages for the use of transplants include more efficient use of expensive hybrid seed, the ability to manipulate planting time, increased crop uniformity, and the accommodation of other production materials, like plastic mulches (Norton, 1968; Liptay et al., 1982; Orzolek, 1991, 1996; NeSmith, 1994, 1997). There is no known literature on the use of transplants with *Cucurbita moschata* cultivars.

Research in 1968 compared three-week-old transplants of muskmelon (*Cucumis melo* L.), another warm-season cucurbit, to field seeded plots that were direct-seeded the same day or 7 to 10 days earlier (Norton, 1968). Results from treatments showed significantly higher yield and fruit weight from transplants. When total soluble solids content of fruit was measured, transplants averaged more than 2% higher than the direct-seeded treatments that were seeded the same day. Total soluble solids content was consistently higher when all transplant treatments were similarly compared to direct-seeded treatments seeded 7 to 10 days earlier. In evaluating time for maturation, transplants were approximately 14 days earlier than treatments seeded the same day, and 7 to 10 days earlier than treatments seeded 7 to 10 days prior to transplanting (Norton, 1968). In Norton's study, the age of the transplant was fixed, while the date of field seeding was variable. Other research indicates that the age of cucurbit transplants may have a significant impact on plant growth and yield (NeSmith, 1993).

A University of Georgia study compared plant growth and fruit yield for summer squash (*Cucurbita pepo* L.) using 10, 20, and 30-day-old transplants. Results indicated that 21 days may be the ideal target age for a summer squash transplant (NeSmith, 1993). A 10-day window following the initial 21days seemed acceptable if transplanting needed to be delayed due to adverse weather. Exceeding 31 days before transplanting presented uncertainties for field applications. In greenhouse trials, transplants planted 28 to 35 days after seeding showed slower growth after planting when compared to transplants seeded 10, 14, or 21 days prior to planting (NeSmith, 1993). In similar research with other cucurbits, muskmelon and watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai], transplant age was found to be non-significant in its effect on fruit yield (Vavrina et al., 1993; NeSmith 1994). Consistently, however, research suggests that transplants should be old enough to withstand handling, but young enough to not have excessive vine growth (Vavrina et al., 1993; NeSmith 1993, 1994). Three-week-old transplants seem to satisfy these criteria and were used in the research to follow.

In 1973, Elmstrom studied the root systems of direct-seeded and transplanted watermelon as a means to understand the differences found related to earliness and total yield performance. Elmstrom theorized that the superior yields of the transplanted treatments were due to the shallow and extensive root systems established shortly after field planting. In comparison, direct-seeded plants produced dominant tap roots which provide for better anchoring and drought tolerance, but may be deficit in the rate of nutrient acquisition when compared to transplanted treatments (Elmstrom, 1973; Barber and Silverbush, 1984). NeSmith (1999) also has credited the rapid root proliferation of transplanted watermelons as an important factor in the earlier establishment and improved total yields when compared to direct-seeded watermelons.

Substituting transplants for direct-seeding in cold climate crop production areas, however, can be inadequate in guaranteeing successful crop establishment and yield improvement. According to Orzolek (1991), there is a 5- to 14-day window after transplanting where plants are susceptible to sun-scald, sandblasting, or mechanical damage from high, constant winds. Exposure to low night temperatures can also slow growth and diminish any beneficial effects of using the transplants. Additional inputs to diminish the effects of the harsh environmental stresses are often recommended for enabling long season crop production in many colder agricultural areas (Orzolek, 1996). As a result, the concept of "microclimate modification and the vegetable crop ecosystem" has been developed (Oebker and Hopen, 1974). Two modification techniques; the use of plastic mulches and row covers, have been widely adapted in the production of cucurbits and fall into the categories of progressive and protective influences on plant development, respectively (Oebker and Hopen, 1974).

Plastic Mulch

Plastic mulch is an example of a progressive, direct influence on the rate of plant growth that will continue as long as the mulch is in place. This type of production technique can modify the soil temperature, conserve soil moisture through a reduction in evaporation, reflect radiant energy into the leaf canopy, maintain good soil structure and aeration, reduce salt problems, affect air temperatures around the plant, and control weeds (which will have an indirect effect on the plant microclimate (Oebker and Hopen, 1974)). Other advantages include higher CO_2 levels around the young plants and reduced fertilizer leaching (Bonanno and Lamont, 1987). These qualities often promote earlier and larger yields in most applications. Researchers have consistently observed positive results in field studies where plastic mulches were applied (Brinen et al., 1979; Bonanno and Lamont, 1987; Handley et al., 1998; Jenni et al., 1998).

In field studies conducted in Florida, Brinen et al. (1979) recorded significant increases in $t \cdot ha^{-1}$ and kg per fruit when comparing mulched plots to bare soil treatments for watermelons. Yields increased from 59.1 $t \cdot ha^{-1}$ to 65.1 $t \cdot ha^{-1}$ for treatments in which plastic mulch was used.

In field studies conducted by the North Carolina State University during the 1984 and 1985 growing seasons, Bonanno and Lamont, (1987) evaluated plastic mulches with and without the addition of a slitted clear plastic row cover. Trials compared bare soil treatments with the use of black plastic or clear plastic on muskmelons. Results included increased total and early yields when using either clear or black plastic as compared to bare soil treatments (Bonanno and Lamont, 1987). Total marketable weight increased from 17.4 $t \cdot ha^{-1}$ to 28.2 $t \cdot ha^{-1}$ when using a plastic mulch in the 1984 study. Treatments conducted in 1985 showed no significant differences in yield for similar comparisons. Soil and air temperature differences between the two growing seasons were offered in explanation. Air temperatures, most notably, were well above normal for 1985 and appeared sufficient to offset any beneficial soil warming effects that may have been provided by the use of plastic (Bonanno and Lamont, 1987).

Similar benefits from the use of plastic mulch were observed during studies conducted in Maine. Handley et al. (1998) recorded an average yield of 20.4 $kg \cdot plot^{-1}$ for 'Earliqueen' muskmelon when grown on black plastic mulch, compared with 9.9 $kg \cdot plot^{-1}$ for treatments where plastic mulch was not used. Plastic mulch also provided for an increase in yield available for "early" harvest. Fruit harvested up to September 2 were counted as "early" yield in this research. Black plastic treatments provided for 36% of the total yield harvested early, compared with 25% for treatments where plastic was not used.

More recently, researchers have evaluated materials other than the black polyethylene that is commonly used. Mulches most commonly discussed in literature reviews other than black embossed polyethylene for growing cucurbits include clear polyethylene and wavelength-selective green polyethylene. Field trials with 'Earligold' muskmelons in Canada evaluated combinations of clear plastic, black plastic, and wavelength-selective mulches incorporated with perforated and non-perforated clear plastic row covers and thermal water tubes (Jenni et al., 1998). Over all treatments, mulch type did not effect early yield when used in conjunction with non-perforated row covers. When perforated row covers were used, clear plastic mulch provided for significantly more early fruits than either black plastic or wavelength-selective mulches. This result was theorized as being due to the stored heat in the soil (of which clear plastic allows for the highest gains) convecting into the air under the tunnel at night (Jenni et al., 1998).

Lamont (1993) summarizes the use of plastic mulches for the intensive production of vegetables by stating that "although a variety of vegetables can be grown successfully using plastic mulches: muskmelons, honeydews, watermelons, squash, [and] cucumbers [...] have shown significant increases in earliness, total yield, and quality". While most research has not examined winter squashes and pumpkins in the array of cucurbits tested for yield improvements related to the use of plastic mulches, there seem to be many consistencies within the Cucurbitaceae family.

Row Covers

Row covers are an example of a protective influence on plant growth, brought about by shielding the effects of the adverse early season growing conditions (Oebker and Hopen, 1974). Tanner (1974), adds that a row cover can also raise the crop temperature at night by preventing heat from convecting away and by protecting against radiation loss. Many row cover studies have focused on site-specific information related to optimum cover-mulch-cultivar combinations for increasing early and total yields. More recently, an understanding of why row covers and plastic mulches improve yields have been documented which may aid in hypothesizing whether these techniques will be effective for the production of *C. moschata* cultivars (Wolfe et al., 1989; Wien et al., 1993; Soltani et al., 1995).

Although no known research has been conducted with calabaza or butternut in conjunction with row covers, many field studies have been conducted at the University of New Hampshire with muskmelon. In 1982, Loy and Wells (1982) compared slitted polyethylene with a spun-bonded polyester material, Reemay™, (a Dupont trademark). Reemay ™ is a light-weight and porous material that was developed with the intention for use without support from wire hoops as is required by polyethylene row covers. Results indicate that early and total yields of 'Goldstar' muskmelon did not differ significantly between row cover treatments. Total yields with either row cover, however, were about 33% higher than yields from treatments where only black plastic mulch was used. Additionally, earliness was increased by approximately one week when both plastic and row covers were used as compared with non-covered plastic mulch treatments (Loy and Wells, 1982).

The row cover treatment comparisons outlined above were performed for four consecutive years and summarized by Wells and Loy (1985). Overall, it was concluded that muskmelons respond similarly to polyester and polypropylene floating row covers. There were, however, a few subtle differences noted. The spun-bonded row cover seemed more effective in excluding airborne insects from vectoring important plant pathogens. Also, melon transplants sustained more damage from row cover abrasion when not supported by hoops during gusty winds (Wells and Loy, 1985). It was concluded that further research would be needed to appropriately evaluate polyester row covers and their significance in horticultural applications.

Similar studies to those performed in New Hampshire were conducted in Oregon during the 1983 and 1984 growing seasons. Three row covers were studied in combinations with black plastic mulch and compared to a bare soil treatment and black plastic mulch alone (Hemphill and Mansour, 1986). Other sources of variance included; direct seeding compared with transplants planted on the same day, and row covers removed “early” compared with row covers removed “late”. The three row covers evaluated were perforated polyethylene, slitted polyethylene, and Reemay™. Overall, type of row cover did not affect yield per plant, mean fruit weight, or percentage of small and large fruit for transplants. All row covers caused peak production to occur 7 to 10 days early, which was comparable to the increase in earliness observed in New Hampshire of approximately one week (Hemphill and Mansour, 1986).

As with plastic mulch materials, input choices for row covers are similarly decided upon related to availability, price, and ease of use (J. Howell, personal communication). Reemay™ was selected in this study for its local availability (Ken-Bar, Reading, MA) and from suggestions previously mentioned relating spun-bonded row covers as a multi-functional production practice for microclimate modification and insect pest protection (Wells and Loy, 1985). Concurrent research was conducted in 1998 and 1999 at the University of Massachusetts Agronomy Farm in South Deerfield, Massachusetts to evaluate row covers as an alternative to pesticides for the control of striped cucumber beetles (*Diabrotica vittata*).

Transplants, Plastic Mulch, and Row Covers

As more "season extension" practices are evaluated, and more resources become available to growers, it becomes valuable to evaluate systems of production that incorporate many methods together for their effect on total and early yield. Two studies previously mentioned were conducted to evaluate the use of three main production practices; transplants, plastic mulch, and row covers.

In 1983 and 1984, Hemphill and Mansour (1986), studied three row covers in combination with black plastic mulch, and compared the use of transplants with direct-seeded treatments. Muskmelons, were started in the greenhouse in peat pellets. These transplants were field planted at 3 to 4 weeks of age and seeds were directly sown into holes punched in black plastic mulch on the same day. Treatments were then covered with either perforated clear polyethylene, slitted clear polyethylene, or spun-bonded polyester row covers. Data was recorded to evaluate total and early yield. Ripe fruits were harvested twice weekly from mid-July until mid-October.

In 1983, all three row covers increased total yield per plant but decreased mean fruit weight. Direct-seeded plants under floating slitted clear polyethylene produced higher total yields and reached peak production earlier than the uncovered transplanted treatments. In 1984, transplants out-yielded direct-seeded plants, but neither total nor early yield were significantly effected by type of row cover (Hemphill and Mansour, 1986). The analysis of data was conducted using Duncan's new multiple range test and it is uncertain, which individual sources of variation had the most impact on total and early yield. In summary, however, it can be deduced that floating row covers were found to increase both total and early yield in muskmelons.

More recently, research was conducted that examined the effectiveness of transplants, plastic mulch, and row covers with 'Earliqueen' muskmelons (Handley et al., 1998). The three main sources of variation were evaluated separately and in various combinations for their effect on early maturity, total yield, and fruit quality.

Thirty-three day old transplants raised in peat pots were planted, or seeds were sown in the field, on June 11, 1997. Black plastic mulch was laid over one half of the plots 12 days prior to planting. Spun-bonded polyester row covers were placed over one-half of the plots and removed on July 23, 1997 (Handley et al., 1998). Fruit were harvested at the half to full "slip" stage from August 27 to September 15, 1997. Fruit harvested up to and including September 2 were counted as fruit harvested "early".

Overall, the use of transplants, when compared to direct seeding, had the greatest effect on improving early yield and total yield of 'Earliqueen' muskmelons. When evaluated as a percent of total yield harvested "early'" (up to September 2), the use of transplants provided for an average of 56% compared to the 5% average recorded for direct-seeded treatments. Results also demonstrated that black plastic mulch increased both early and total yields. Total yields of fruit increased from 10 kg to 20 kg when bare soil treatments were compared to treatments that included plastic mulch. Mulched treatments also provided about 10% more yield harvested "early" than bare soil treatments. The use of row covers, in this study, was reported inconsistent in providing significant yield increases. Cool, wet, cloudy weather was speculated as the cause of these inconsistent row cover results, due to a reduced ability of the covers to collect and retain heat. The best plant growth and highest yields were recorded when all season extension techniques were used together (Handley et. al., 1998).

It was hypothesized that calabaza and butternut squash would respond similarly to the production techniques outlined above. The research to follow evaluated the effects of utilizing black plastic mulch, polyester spun-bonded row cover, and transplanted seedlings on the early and total yield response of two *Cucurbita moschata* cultivars.

Objectives

The objectives of this study were to:

1. Evaluate the effect of transplants, plastic mulch, and row covers on overall yield of calabaza with respect to butternut squash.
2. Evaluate the effect of transplants, plastic mulch, and row covers on the early fruit set and maturation of calabaza.

CHAPTER 2

PRODUCTION OF CALABAZA, *CUCURBITA MOSCHATA* DUCHESNE, FOR DIRECT MARKET SALE IN MASSACHUSETTS USING TRANSPLANTS, PLASTIC MULCH, AND ROW COVER

Abstract

Field studies were conducted in 1998 and 1999 to record the effects of transplants, black embossed plastic mulch, and polyester spun-bonded row cover (Reemay™) on the progression of fruit set and total yield of *Cucurbita moschata* Duchesne cultivars C42 ×La Segunda calabaza and Waltham butternut squash in Massachusetts. Treatments included direct-seeding, transplanting, non-mulched conditions, and plots mulched with black embossed plastic, all with and without the addition of a row cover supported by 9 gauge wire hoops. Transplants, as compared to plastic mulch and row cover, produced the most consistent results with the greatest differential in early yield potential for calabaza (as determined by date of 10% fruit set) and total actual yields for both cultivars. Date of 10% fruit set was significantly advanced with the use of transplants by an average of 7 days in both research years. Plastic mulch and row covers also significantly advanced early fruit set by 7 days but only in 1998. Calabaza was more responsive to treatment effects and produced nearly twice the yields of butternut squash on a per hectare basis. Transplants, plastic mulch, row cover, or any combination of the three, produced significant quantities of mature product available for sale prior to Labor Day in Massachusetts. Transplant treatments averaged 909 projected fruit per ha available for

Labor Day markets. Average yield results for calabaza were 4 fruit per plant with a mean weight of 5.5 kg per fruit. Production goals of 39 $t \cdot ha^{-1}$ were met in both years. Calabaza should be considered a viable crop alternative for vegetable producers in the Northeast.[1]

Introduction

Calabaza (*Cucurbita moschata* Duchesne) is a tropical pumpkin of great importance to many Latin American cultures and is predominantly grown in Puerto Rico, the Dominican Republic, Costa Rica, Mexico, and far southern portions of the United States (Pearrow and Plummer, 1991). As of 1993, calabaza production in southern Florida had risen to 1000 ha, grossing over $5 million (Maynard and Elmstrom, 1993). Calabaza consumed in the Northeastern portion of the United States is largely imported from the aforementioned areas and is typically of very poor quality by the time it is received at terminal markets and then distributed to the end consumer (Carter, personal communication). Over the past few years, Latinos have addressed their interest in growing and purchasing vegetables native to their countries to members of the UMass Extension Vegetable and Small Fruit Team (F.X. Mangan, personal communication). Calabaza is the most important non-root crop consumed in Puerto Rico (Maynard and Elmstrom, 1993) and due to a dominance of Puerto Ricans and Dominicans among Latinos in Massachusetts, there is particular interest in growing crops specific to their respective cultures.

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[1] This material is based upon work supported by the Cooperative State Research, Extension, Education Service, U.S. Department of Agriculture, Massachusetts State Agricultural Experiment Station under Hatch Project No. MAS00786.

Cucurbits like calabaza are tropical or subtropical in origin and can be particularly sensitive to cold temperatures. Consequentially, these warm-season crops, when grown under cool conditions, can be particularly responsive to treatments aimed at accelerating development and increasing yields (Wells and Loy, 1985; Waterer, 1993; Jenni et al, 1998). According to Orzolek (1991), the best method for improving yields is to ensure optimal crop establishment, which relates to both plant population and acclimation.

Transplanting greenhouse produced seedlings, as opposed to seeding directly into the soil, is one such strategy for the improvement of crop establishment, and subsequently on overall yields. Although there is no research which investigates the use of transplants with calabaza or other *Cucurbita moschata* cultivars, like butternut squash, other warm-season cucurbits, muskmelon (*Cucumis melo* L.), summer squash (*Cucurbita pepo* L.), and watermelon [*Citrullus lanatus* (Thunb.) Mansf.] have been extensively evaluated (Norton, 1968; Hemphill and Mansour, 1986; Hall, 1989; Vavrina et al., 1993; Handley et al., 1998; NeSmith, 1993, 1994, 1997, 1999). Results indicate that cucurbit transplants can consistently produce higher total yields and additionally can provide for accelerated maturation, by approximately 14 days, when compared to direct-seeded treatments planted on the same day (Norton, 1968; Hemphill and Mansour, 1986). The superior yields of transplanted cucurbit seedlings have been documented to be a result of the shallow and extensive root systems established shortly after field planting. In comparison, direct-seeded plants produced dominant tap roots which provide for better anchoring and drought tolerance, but may be deficit in the rate of nutrient acquisition when compared to transplanted treatments (Elmstrom, 1973; Barber and Silverbush, 1984; NeSmith, 1999).

Plastic mulch can also directly influence plant establishment and the rate of plant growth through modification of soil temperature, conservation of soil moisture, maintenance of soil structure, reduction of salt problems, reduction of resource competition from weeds, and diminished nutrient leaching (Oebker and Hopen, 1974; Bonnano and Lamont, 1987). Researchers have consistently observed positive yield results in field applications with the use of plastic mulches, often directly related to the microclimate benefits (Brinen et al., 1979; Bonnano and Lamont, 1987; Handley et al., 1998; Jenni et al., 1998). Vegetable growers now have access to a wide selection of plastic mulch materials. Although research into new formulations of degradable, wave-length selective, and colored plastic is on-going, black mulch is predominate in U.S. production systems (Lamont, 1993) and has been the type most often studied with cucurbits (Hemphill and Mansour, 1986; Marr et al., 1991; Waterer, 1993; Soltani et al., 1995; Handley et al., 1998; Sanders et al., 1999). Lamont (1993) has summarized that cucurbits are among the most benefitted crops when grown with plastic mulches and have shown significant advanced fruit set and maturation, increased total yields, and improved quality.

Row covers can also provide benefits to plant growth which can not be realized through the use of transplants or plastic mulch. The protection from adverse climate conditions and the ability to raise the crop temperature through the prevention of convective or radiant heat loss are commonly a significant benefit in producing increased and earlier yields (Oebker and Hopen, 1974; Tanner, 1974). Results from research with muskmelon indicate that total yields can be increased and harvest can be advanced, by approximately one week, when row covers are used over plastic mulch and compared with non-covered plastic mulch (Loy and Wells, 1982, Wells and Loy, 1985; Hemphill and Mansour, 1986).

Winter squashes have not been tested as extensively as summer squashes and melons. It is hypothesized that *C. moschata* cultivars, which are warm-season cucurbits, would respond similarly to the production techniques outlined above. This study evaluated the effects of using transplants, black plastic mulch, and spun-bonded polyester row cover on harvest advancement (earliness) and total yield of calabaza in relation to a comparable cultivar commonly produced in Massachusetts, butternut squash.

Materials and Methods

Cucurbita moschata Duchesne cultivars C42 ×La Segunda calabaza (University of Florida Gulf Coast Research and Extension Education Center) and Waltham butternut squash (Johnny's Selected Seed, Albion, Maine) were evaluated at the University of Massachusetts Agronomy Farm in South Deerfield, Massachusetts in 1998 and 1999.

'C42 ×La Segunda' calabaza is a piebald green, somewhat flattened, round fruit with a deep yellow/orange sweet flesh. Fruit weight can range from 2 to 10 kg. Flesh is smooth textured and each short-vine plant can yield an average of 2 to 4 fruit. Researchers in Florida have set breeding goals around the yield parameters of producing 39 $t \cdot ha^{-1}$ with 60% of the fruit weighing between 3.6 and 6.8 kg (Maynard, personal communication).

The University of Florida Gulf Coast Research and Extension Education Center recommends up to 120 days for fruit maturation, depending on the variety. Tracking fruit development 50 days following anthesis was determined to be the most consistent method for assuring maturation of calabaza (Unander and Varela-Ramirez, 1988). In this study, flowers at anthesis were tagged weekly to track fruit set progression and project fruit availability potential for Labor Day sales. Only data for marketable fruit was utilized within fruit set progression analyses.

Butternut is a light tan winter squash with a small seed cavity and a thick, cylindrical neck without a crook. Johnny's Selected Seeds recommends 105 days for fruit maturation. Uniform fruits average 23 cm in length and 2 kg in weight. Flesh is smooth textured and each short-vine plant can yield an average of 4 to 5 fruit. 'Waltham' was the cultivar chosen as the industry standard grown in New England. Growers of butternut squash in Massachusetts have not expressed an interest in having a product available for Labor Day markets. Fruit set progression analyses were not conducted for butternut.

A randomized complete block design with four replications was utilized for analysis. Each block consisted of sixteen plots, arranged randomly amongst the two cultivars. The eight treatments evaluated in both 1998 and 1999 were: 1) direct-seeded/non-mulched/non-covered (TR_0-PL_0-RC_0); 2) direct-seeded/mulched/non-covered (TR_0-PL_1-RC_0); 3) direct-seeded/non-mulched/covered (TR_0-PL_0-RC_1); 4) direct-seeded/mulched/covered (TR_0-PL_1-RC_1); 5) transplanted/non-mulched/non-covered (TR_1-PL_0-RC_0); 6) transplanted/mulched/non-covered (TR_1-PL_1-RC_0); 7) transplanted/non-mulched/covered (TR_1-PL_0-RC_1); and 8) transplanted/mulched/covered (TR_1-PL_1-RC_1).

Soil type in research areas is an occum fine sandy loam variant (coarse-loamy, mixed, mesic fluventic dystrocrept). In both years, soil samples were taken following fall sown winter rye plow down in the spring. Fertilizer (Urea, 30N-0P-0K, Crop Production Services, Deerfield, MA) was broadcast at 56 $kg \cdot ha^{-1}$ N and incorporated using a disc harrow as recommended by the New England Vegetable Management Guide (Ferro, ed., 1999). Mulch was a black embossed plastic 1.25 mil x 0.9 m-wide material (Griffin Greenhouse Supply, Tewksbury, MA.). Mulch was mechanically laid. Nine gauge wire hoops cut to 1.7 m were set 1.2 m apart in the row for the appropriate row cover treatment plots prior to planting. Three-week-old transplants of each cultivar, grown in 5 cm^3 peat pots [Jiffy Products (N.B.) LTD., Shippagan, Canada] and sterile potting mix (PRO-MIX BX, Premier Horticultural Inc., Red Hill, PA), were planted, or seeds were directly sown, the first week in June for each research year. All plant locations were watered upon planting. Covered treatments utilized a 1.7 m-wide spun-bonded polyester row cover, trade name 'Reemay™' (Ken-Bar, Reading, MA), laid over the hoops, forming a tunnel, for appropriate plots immediately following watering.

Plots were 6 m long. Plants were spaced 1.2 m apart in the row and 6 m between rows. Each plot consisted of 10 plants in two rows and represented 37 square meters or 0.004 hectares. Calabaza plots were monitored twice weekly for flower initiation. Direct-seeded treatments were thinned to one plant per 1.2 m in row. Weeds were controlled mechanically. Pre-vining side dress soil samples for nitrogen were taken and fertilizer (Prolific, 20N-20P-20K, Terra International Inc., Sioux City, Iowa) was applied as an aqueous solution at a rate of 56 $kg \cdot ha^{-1}$ nitrogen in 1998. In 1999, a pre-side dress nitrogen test did not indicate that a side-dress of nitrogen was required. Row covers were removed at first flower initiation to allow for pollination. Transplant treatment row covers were removed the second week of July in each year. Successfully pollinated flowers were tagged weekly and marked to approximate a date of fruit set and to project a date for maturation. Vines were trained manually to keep treatments separate. A single harvest date was chosen for each selection in each year. All fruit within a selection were cut from the vine and allowed to cure in the field for a minimum of one week. Fruit was counted and weighed. Tags were collected and compared to tag dates previously recorded to track aborted fruits. The date of 10% of fruit set was calculated in both years for all treatments as an indicator of earliness.

Data was analyzed using analysis of variance on SAS (SAS v6.12 for Windows, SAS Institute, Inc., Cary, NC). Overall variance was evaluated over both *Cucurbita moschata* cultivars to establish significance of treatment effect on yield weight, number of fruit, and progression of fruit set.

Results

Growing conditions and field observations. Each year of research presented environmental stress of significant levels that varied from cold and wet to hot and dry. In 1998, rainfall was significantly above 50 year averages for the months of May and June and was also below average temperature during June and July (Table 2.1). Field conditions were also windy and cold for approximately 6 days following field establishment. Various herbivore pests (e.g. woodchucks and mice) were also problematic and diminished plant populations beyond what could be replenished (Table 2.2) by extra transplants. Damage was predominant with direct-seeded plots that were not covered. July, August, and September of 1998 were all well below average precipitation.

In 1999, May, June, and July were well below the 51 year averages for rainfall and were consistently above average temperature (Table 2.1). Much of the Northeast was effected by drought conditions and no irrigation was utilized following the initial watering of the plants. However, 2.54 cm rain was received 5 days after planting in 1999. Herbivore pests in 1999 were less of a problem. Evaluation of data using plant population as a covariant within a General Linear Model (GLM) analysis was non-significant for both years. Weekly and total fruit set (for calabaza), number of fruit per plant, average fruit weight, and total yields, were significantly higher in 1999 when compared to the same treatments in 1998 (Tables 2.3a, 2.3b, 2.4, and 2.5, Figures 2.1and 2.2). In tracking progression of fruit set for calabaza, first tagged female flower at anthesis occurred by the week of July 10th (approximately 60 DAP) in both research years (for all transplanted treatments in 1998 and for transplanted treatments with plastic mulch and row cover in 1999). Fruit set accelerated between July 30th and August 20th (approximately 74 to 95 DAP) (Figures 2.1 and 2.2). Between 3 and 4 weeks after field planting, transplants under row cover on plastic were vining and beginning to flower (male flower initiation). For direct-seeded treatments, this stage of development occurred approximately 14 days later.

*Cucurbita moschata cultivar*s. In general, calabaza produced an average of 4 fruits per plant (Table 2.6), with an average size of 5.5 kg. Butternut produced an average of 7 fruits per plant (Table 2.7) with an average size of 1.6 kg. Significant differences were recorded among cultivars in relation to the growing conditions of each year [cultivar(C) x year(Y) interactions] (Table 2.3b). When evaluating number of fruit per plant over both years, only butternut yield differences were significant ($P \leq 0.01$). Conversely, average fruit size differences between seasons were only significant for calabaza ($P \leq 0.01$). In both examples, numbers for 1999 exceeded those of 1998. Both cultivars produced significantly higher total yields in 1999.

Transplants. The differential in calabaza total fruit set was highest when comparing transplants to direct-seeded treatments and when considering all other treatment main effects (Figures 2.1, 2.2, and 2.3). Total fruit set was significantly higher in 1999 (Figure 2.1). The date of 10% fruit set was significantly advanced with the use of transplants by an average of 7 days in both years. In comparing fruit set by July 23rd (approximately 50 days prior to Labor Day), transplants provided the highest totals in both years (673 and 1144 fruit per ha for 1998 and 1999 respectively).

Transplanted treatments also resulted in higher values for total yield evaluated over both selections and both years. Total yields were 48 $t \cdot ha^{-1}$ for transplants and 33 $t \cdot ha^{-1}$ for direct-seeded treatments ($P \leq 0.01$) (Table 2.3a). This effect on total yield was consistent with significantly higher values recorded for average number of fruit per plant (5.9 for transplants and 4.8 for direct seeded) and average fruit size (3.8 kg for transplants and 3.3 kg for direct-seeded) (Table 2.3a). There was a highly significant Y x TR interaction in evaluating total yields.

In separating means, both TR:98 and TR:99 were highly significant, although 1999 accounted for the majority of the sums of squares. Yield values when analyzing this interaction in 1999 were 58 $t \cdot ha^{-1}$ for transplants and 38 $t \cdot ha^{-1}$ for direct-seeded treatments (Table 2.5) compared to 39 $t \cdot ha^{-1}$ and 28 $t \cdot ha^{-1}$ for the respective treatments in 1998 (Table 2.4). There were also highly significant C x TR interactions in evaluating total yields (Table 2.3b). Both cultivar interactions with the use of transplants were highly significant. Calabaza, however, did account for the largest portion of sum of squares when evaluating total yields for this interaction with an average of 64 $t \cdot ha^{-1}$ for transplants and 41 $t \cdot ha^{-1}$ for direct-seeded treatments (Table 2.6). Butternut transplant treatments averaged 33 $t \cdot ha^{-1}$

compared to 25 $t{\cdot}ha^{-1}$ for direct-seeding (Table 2.7). Evaluation of average fruit size also resulted in a C x TR interaction where only TR:Calabaza differences were significant. Fruit size for calabaza was higher for transplanted treatments, averaging 5.8 kg per fruit, compared to 5.0 kg for direct-seeded plots (Table 2.6). Butternut fruit weights differed by 0.1 kg when comparing transplants with direct-seeded treatments (1.7 kg and 1.6 kg, respectively) (Table 2.7). This difference was only statistically significant when evaluating butternut by itself, over 98 and 99.

In looking at yield results for each cultivar individually, there were also Y x TR interactions that needed to be separated (Tables 2.6 and 2.7). In all situations, 1999 was found to account for the largest apportionment of sum of squares.

Plastic mulch. Plastic mulch treatments provided the second largest differential in total calabaza fruit set in 1999 and the third largest in 1998 (Figure 2.2) when compared to non-mulched treatments and when considering all other treatment main effects. In 1999, the hotter/drier year, plastic mulch provided a greater differential in total fruit set when compared to row cover/non-covered treatments (Figure 2.2). The reverse was true in 1998, the cooler/wetter year. The date of 10% fruit set was significantly advanced with the use of plastic mulch by an average of 7 days in 1998 only (Figure 2.2). In comparing fruit set by July 23rd (50 days prior to Labor Day), plastic mulch provided for 555 fruit per ha, compared with 118 for non-mulched treatments in 1998 (Table A.1). In 1999, the differential was less, with mulched treatments averaging 639 fruit per ha and non-mulched averaging 521 fruit per ha (Table A.2). Total fruit set in 1999 for non-mulched treatments was higher than the mulched treatments in 1998 (Figure 2.2).

Total yields were significantly higher when plastic mulch treatments were compared to non-mulched (Table 2.3a). Total yields of 44 $t \cdot ha^{-1}$ for PL and 37 $t \cdot ha^{-1}$ for non-mulched treatments were recorded averaged over both cultivars and both years. Plastic mulch had no significant effect on average fruit size (Table 2.3a), although number of fruit per plant was significantly higher when plastic mulch was used. Averages of 5.9 and 4.8 fruit per plant were recorded for mulched and non-mulched treatments, respectively. There was also a significant Y x PL interaction in evaluating total yields. Although PL:98 and PL:99 were both statistically significant, sum of squares were primarily accounted for in 1999, where total yields for mulched and non-mulched treatments were 53 $t \cdot ha^{-1}$ and 43 $t \cdot ha^{-1}$ compared to 36 $t \cdot ha^{-1}$ and 31 $t \cdot ha^{-1}$ for the respective treatments as recorded in 1998 (Tables 2.4 and 2.5).

Row covers. Row cover treatments provided the second largest differential in total calabaza fruit set in 1998 and the third largest in 1999 (Figure 2.3) (the opposite results observed with mulch treatments) when compared to non-covered treatments and when considering all other treatment main effects. The date of 10% fruit set was significantly advanced with the use of row covers by an average of 7 days in 1998 only (Figure 2.3). In comparing fruit set by July 23rd (50 days prior to Labor Day), row covers provided for 387 fruit per ha, compared with 286 for non-covered treatments in 1998 (Table A.1). In 1999 the differential was less, with covered treatments averaging 606 fruit per ha and non-covered averaging 555 fruit per ha (Table A.2). As with the plastic mulch treatments, the total fruit set in 1999 for non-covered treatments was higher than the covered treatments in 1998 (Figure 2.2).

Total yield data comparing row covers to non-covered treatments is more complex. As with plastic mulch treatments, row covers significantly affected average numbers of fruit per plant and total yields, but did not effect average fruit weight when averaging both cultivars over both years (Table 2.3a). Total yields for covered plots averaged 44 $t \cdot ha^{-1}$ compared to 38 $t \cdot ha^{-1}$ for non-covered plots. Also, fruit per plant numbers compared at 5.5 fruit per plant and 5.2 for covered and non-covered plots, respectively. Complexities arise with Y x RC, C x RC, and C x Y x RC interactions (Table 2.3b).

For Y x RC interactions, every apportionment of sum of squares resulted in 1998 accounting for the most significant share of the total, even though mean separation indicated both RC:98 and RC:99 to be highly significant (Table 2.3b). For the C x RC interaction, apportionment indicated that calabaza had accounted for the largest share of the total, $P \leq 0.01$ for RC:Calabaza, when evaluating effect on total yield, where $P \leq 0.05$ for RC:Butternut. The two year averages for each cultivar were 57 $t \cdot ha^{-1}$ and 48 $t \cdot ha^{-1}$ for calabaza, covered and non-covered, respectively, and 31 $t \cdot ha^{-1}$ compared to 27 $t \cdot ha^{-1}$ for the comparable treatments with butternut (Tables 2.6 and 2.7). In separating C x Y x RC interactions, results were split amongst cultivars. Analysis of number of fruit per plant resulted in significant differences for butternut only in 1998. Averages were 6.3 fruit per plant and 5.4 fruit per plant for covered treatments compared to non-covered treatments, respectively (Table 2.8). In 1999, only calabaza had significantly different numbers of fruit per plant. Averages were 4.4 and 3.9 fruit per plant for row cover versus non-covered treatments (Table 2.11).

Transplants, plastic mulch, and row covers. There were numerous interactions among treatment main effects that were of significance. Analysis of yield data over both cultivars in both years also resulted in significant treatment interactions. A TR x PL interaction in the analysis of number of fruit per plant showed significance for both TR:bare soil and TR:PL interactions. The majority of sum of squares was accounted for with the use of transplants with non-mulched soil. Evaluation of average fruit weight indicated a Y x PL x RC interaction, which upon mean separation showed significance for 1999:RC:Plastic only (Table 2.3b). A C x Y x PL x RC interaction of significance was also found in relation to average fruit size. This interaction was confirmed in analysis of calabaza data separately (Table 2.6). The mean separations resulted in the combination RC with PL accounting for the largest portion of sum of squares ($P \leq 0.01$), when compared to the RC with bare soil treatments ($P \leq 0.05$).

Discussion

Field conditions during the first two weeks after transplanting were cool, wet, and windy. These qualities, combined with herbivore pressure on the newly emerging seedlings, were enough to effect plant populations (Table 2.2). Field observations led to the assumption that the direct-seeded plant numbers were more effected than the transplants by the climate and pests. These observations were statistically validated in 1998 (Table 2.2). Direct-seeded plots averaged 2250 plants per ha compared with 2500 for plots where transplants were used in 1998 (data not shown). Climate data for 1999 confirmed field observations of a very dry and hot year, with much of the Northeast reaching 100 year highs in temperature and lows in precipitation. These conditions, however, did not present problems for growing calabaza. On the contrary, yields were significantly higher in 1999 when compared with 1998 (Tables 2.4 and 2.5). Plant populations were not significantly effected by climate or pests in 1999, although row cover effect on plant populations was consistently beneficial when evaluated over both seasons (Table 2.2). In both years, non-covered treatments had 125 less plants per ha, on average, when compared to covered treatments by years end (Table 2.2). Therefore, the use of transplants and row covers for improved plant establishment related to total plant population was of significant importance in the results of this research. Transplants apparently were not as attractive to the pests because of their coarse stems and larger leaves when compared to the more succulent direct-seeded seedlings, and covered plots were less accessible to being eaten or affected by wind and cold. The plant population variances, however, did not confound yields per plant or size of fruit (data not shown).

Other research has supported increased yields of transplanted cucurbits, in part, due to improved establishment due to plant acclimation as well as total plant population (Elmstron, 1973; NeSmith, 1999). These studies have analyzed the root systems of direct-seeded and transplanted watermelons. It was found that often the root profile and related total yields would be comparable 11-12 weeks after planting for both plant establishment methods (NeSmith, 1999). Conclusions were made that advanced physiological age is not enough to ensure superior growth and yields. If cold weather was present at field planting, growth of either direct-seeded or transplanted cucurbits would be delayed. It would then be of great value to utilize other production practices to insure stand establishment and subsequent improved total yields.

Both cultivars, in both years, exhibited growth and yield results similar to other cucurbit species that have been studied for response to "season extension" practices, although, calabaza was generally more responsive to treatment effects. In evaluating yield, as an example, calabaza showed a significantly greater differential between direct-seeded and transplanted treatments than the comparable butternut treatments. Although butternut produces far more fruit per plant, the size variance significantly favors the yield potential of calabaza on a per hectare basis. Calabaza averaged 53 $t{\cdot}ha^{-1}$ compared to the 26 $t{\cdot}ha^{-1}$ for butternut (Table 2.6). This data is important for direct-sale growers who serve markets visited by Latinos or wholesale crop producers. Market prices for butternut and calabaza are fairly comparable in Massachusetts (Mangan, personal communication). With this in mind, a grower could approximately double gross returns by switching some production to calabaza if they had access to the markets for the crop.

Tracking flowers reaching anthesis and successfully developing into mature fruit showed that regardless of treatment main effect or the climate, the cumulative fruit set is very comparable. From the first date of female flower anthesis through another 21 days fruit set is relatively slow. Accelerated female flower production then occurred for a 21 day period, and then eventually tapered off. Transplants were, by far, the most reliable treatment method for producing the most fruit per hectare, regardless of climate, although transplant effect on yield was significantly greater in 1999. In studies of calabaza in the tropics, drought conditions from the period of bushy growth to male flowering was found to be the most limiting factor for yield (Rios et al. 1998). In our study, using transplants advanced when the plants reached first male flower in the field and may have lessened the severity of the drought on total yield. At all stages of plant development, there was precipitation in each year which prevented the plants from experiencing a true drought and may help explain the yield results.

For a long-season crop like calabaza, the hastened establishment of roots and the subsequent access to nutrients seem to outweigh the microclimate modification traits of plastic mulch and row covers. Also, the use of plastic mulch or row cover produced fruit number differentials varied depending on the climate conditions of the growing season. In the cooler/wetter of the two seasons, row covers provided for a greater number of total fruit produced per hectare compared to plastic mulch treatments. Protection from wind and increased daytime temperatures under the row covers during the cool spring days seemed to benefit the plants to a larger extent than the ability of plastic mulch to prevent nutrient leaching and increase soil temperatures. In the hotter/drier year (1999) plastic mulch provided for a higher differential in fruit produced (over non-mulched treatments) when compared to row cover differentials. In a drought year, the benefits of moisture conservation seem to outweigh the benefits which row covers provide, especially when cool temperatures are not a factor in growth.

Significant differences between calabaza and butternut squash were also found when comparing fruit size variability. Regardless of treatment or conditions, calabaza fruit size varied significantly where butternut differences in size were consistently non-significant. ‘Waltham’ butternut’s consistency may be due to having been bred for commercial production in Massachusetts to produce a viable, uniform crop for many years. It is possible that calabaza can also be selected for these same traits and adapt to Northern growing season length with less reliance on “season extension” materials. Both cultivars yielded more when transplants, plastic mulch, or row covers were used.

Based on the results of the presented project, and the breeding preference characteristics for yield developed in Florida (Maynard, personal communication), production of calabaza in Massachusetts seems viable in conjunction with any of the production methods utilized in this research. Average yields over all treatments were similar to the 39 $t \cdot ha^{-1}$ goal of Florida producers (28 to 85 $t \cdot ha^{-1}$). Unfortunately, however, seed for the cultivar used in this study is not yet available commercially. Other selections are available in small quantities from small seed companies, but commercial adaptability can be less consistent than the evaluated hybrid.

Regardless of the growing conditions or cultivars, transplants provided the most consistent results for early harvest potential (based on the number of fruit set 50 days prior to Labor Day) and for total yield traits (fruit size, number, and total weight). This data can be added to the research done with muskmelon (Norton, 1968; NeSmith, 1994; Handley, et. al., 1998), watermelon (NeSmith, 1999), and summer squash (NeSmith, 1993). Data from our 1998-99 studies suggest that the total yield response of transplants was partially due, in 1998, to improved stand establishment, or more simply, that transplants more readily assured a larger number of surviving plants per hectare than did direct-seeding . Transplants of cucurbits have also been shown to acclimate quickly due to rapid root proliferation, and possibly due to the type of root systems which develop (Elmstrom, 1973; Orzolek, 1991; Wien, et.al., 1993; NeSmith, 1999).

Transplanted cucurbits generally lack a dominant tap root, yet possess extensive shallow root branching which may be advantageous for early water acquisition and nutrient uptake (Elmstrom, 1973; NeSmith, 1999). This accelerated accessibility to resources can benefit crop establishment, advance peak production, and lead to the avoidance of late-season climate or disease problems which translate into decreased yields and crop marketability (Norton, 1968).

Field observations of early vegetative growth suggested that transplants were approximately 14 days ahead of direct seeded counterparts. Row cover removal at first male flower, to allow for pollination, was generally 35 days after field planting for transplant×row cover treatments and 12 to 14 days later for direct-seeded×row cover plots. Similarly, the beginning of calabaza fruit set in this study was advanced an average of 14 days for transplanted treatments in 1998 and less than 14 days in 1999 (Tables A.1 and A.2). This data supports earlier work by Norton (1968) and Hemphill and Mansour (1986). Both studies found that fruit maturation occurred approximately 14 days earlier than direct-seeded plants.

Use of plastic mulch also showed fairly consistent results on total yields through both growing seasons but not to the degree exhibited by the use of transplants. Results from the two climatically different years were also possibly in response to different benefits of using black plastic mulch. In 1998, the mulch layer may have reduced nutrient leaching and possibly warmed the soil to benefit plant growth. Pre-sidedress nitrogen tests (PSNT) in 1998 showed only 9 ppm N in bare soil plots compared with 25 ppm N under plastic mulch (data not shown). Plastic mulch had a significant effect on date to 10% fruit set, number of fruit per plant, and total yields in 1998 (Table 2.4). In 1999, moisture was possibly conserved in areas surrounding the plants, diminishing the effects of a below normal rainfall season (Table 2.1). PSNT in 1999 indicated adequate nitrogen in both bare soil plots and in mulched plots. However, unlike 1998, plastic mulch effect on cumulative fruit set and number of fruit per plant were non-significant in 1999. Above average temperatures (Table 2.1) or inadequate moisture prior to laying the plastic may have greatly diminished the many benefits of the mulch and may explain the results found in Table 2.5 for 1999. Similar conclusions have been made in regard to non-significant results from using “season extension” materials to improve yields in above normal climatic years (Bonnano and Lamont, 1987). Additionally, plastic mulch did not effect fruit size in either year. Benefits in yield were thus related mostly to the production of more fruit per plant which was similarly found for row cover treatments in our study and others (Hemhill and Mansour, 1986).

Spun-bonded polyester row cover use in 1998 was significant in providing an advanced date of 10% fruit set and higher yields, which can probably be correlated to its buffering of the cold and wet climate for stand establishment and acceleration of degree day accumulation (Loy and Wells, 1982). The wire hoops utilized in this study also protected the plants from abrasive damage by the row cover during hard rains and gusty winds. Although solar radiation data was not collected as part of this research, statistical significance for early and total yield data suggests that the conditions were adequate to benefit from a cultural practice that can transmit radiant energy from the sun during the day and reduce heat loss from thermal radiation at night (Tanner, 1974). Increases in heat accumulation units have been offered as an explanation for row cover effectiveness in yield improvement, though most benefit is from higher daytime means and not higher nighttime temperatures (Wolfe, et. al., 1989; Jenni, et. al., 1998).

Row cover use in the warm, dry climate of 1999 presented no significance in affecting advanced fruit set or total yields but may have served to provide wind intensity reduction, microclimate modification, insect pest protection, and reduction in soil mechanical resistance (Wells and Loy, 1985; Hemphill and Crabtree, 1988; Waterer, 1993). Row covers have been shown to play an important role in acting as an anticrustant and maintaining the aggregate structure of soil particles by reducing rain impact or maintaining soil surface moisture (Hemphill and Crabtree, 1988).

Growers looking to advance the availability of, or increase, *C. moschata* yields will benefit from the use of transplants, plastic mulch, and/or row covers. To economically justify the use of these treatments, growers would need to weigh available resources (e.g. a greenhouse for seedling production), available markets for the crop, and market prices related to when the crop would mature. The use of transplants, plastic mulch, or spun-bonded polyester row cover for the production of calabaza and butternut squash can provide for increased yields and advanced availability for direct market sales in Massachusetts. Additionally, the use of these "season extension" techniques can be intentionally selected in various combinations to provide for a consistent supply of mature fruit from September through the end of the season. The grower then has the option for direct-sales or wholesale markets and can take advantage of market price variability by having a product over a wider span of time. There is no combination of production practices that will work best in all seasons. Climate factors are far too variable and it would be difficult for a farmer to predict what inputs would work best by field planting time (late May in Massachusetts). Therefore, some risk will need to be taken. Transplants seem consistently low risk for both advancing early fruit set and increasing total yields. Growers could keep some row covers available for cool springs or when stripped cucumber beetle control is desired. The plastic mulch decision would need to be based on weed control strategies and what other production techniques the grower utilizes. For growers who use drip irrigation systems, plastic mulch is almost synonymous. For growers who use overhead irrigation, research suggests non-plastic mulch options work best (NeSmith, 1997).

Table 2.1. Mean rainfall and temperature for Massachusetts growing seasons 1998 and 1999 (collected at the Amherst College weather station in Amherst, MA.).

	Rainfall (centimeters)			Temperature (°C)		
	1998	1999	NORM(98/99)	1998	1999	NORM(98/99)
May	14.7	9.0	9.9/9.9	17.6	16.4	14.8/14.8
June	20.5	7.7	9.4/9.3	19.5	21.6	19.7/19.7
July	7.4	4.5	9.9/9.8	22.3	24.2	22.5//22.5
August	3.1	11.5	10.3/10.2	22.7	21.3	21.4/21.4
September	7.9	34.3	9.0/9.5	18.3	18.6	16.8/16.8

Table 2.2. Calabaza and butternut: Treatment effect on plant population per hectare over 1998 and 1999.

Main effects	Plant population average per hectare 1998/99
Direct seeded(TR_0)	2350
Transplanted(TR_1)	2425^{NS}
Non-mulched(PL_0)	2375
Plastic mulch(PL_1)	2400^{NS}
Non-covered(RC_0)	2325
Row cover(RC_1)	2450**

‡All other interactions not listed are non-significant
^{NS} = $P>0.05$
* = $P\leq0.05$
** = $P\leq0.01$

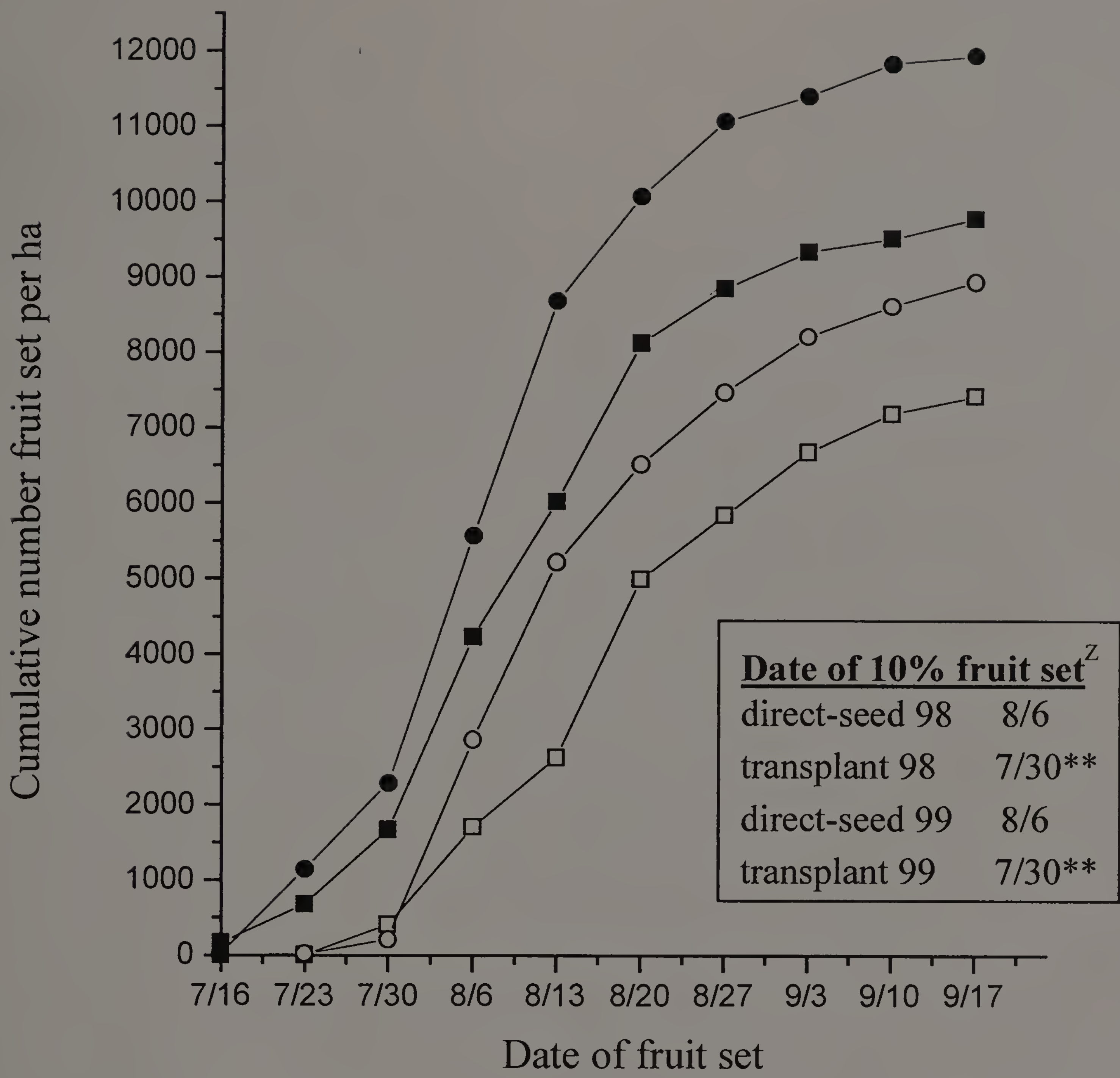

Figure 2.1. Cumulative fruit set as effected by direct-seeding or transplanting in 1998 and 1999 (□-direct-seeded 1998, ■-transplanted 1998, ○-direct-seeded 1999, ●-transplanted 1999).

^{Z} = Date of 10% fruit set is an adjusted average based on all fruit tagged at anthesis by the above dates for the appropriate treatments. ^{NS} = $P>0.05$, * = $P\leq0.05$, ** = $P\leq0.01$.

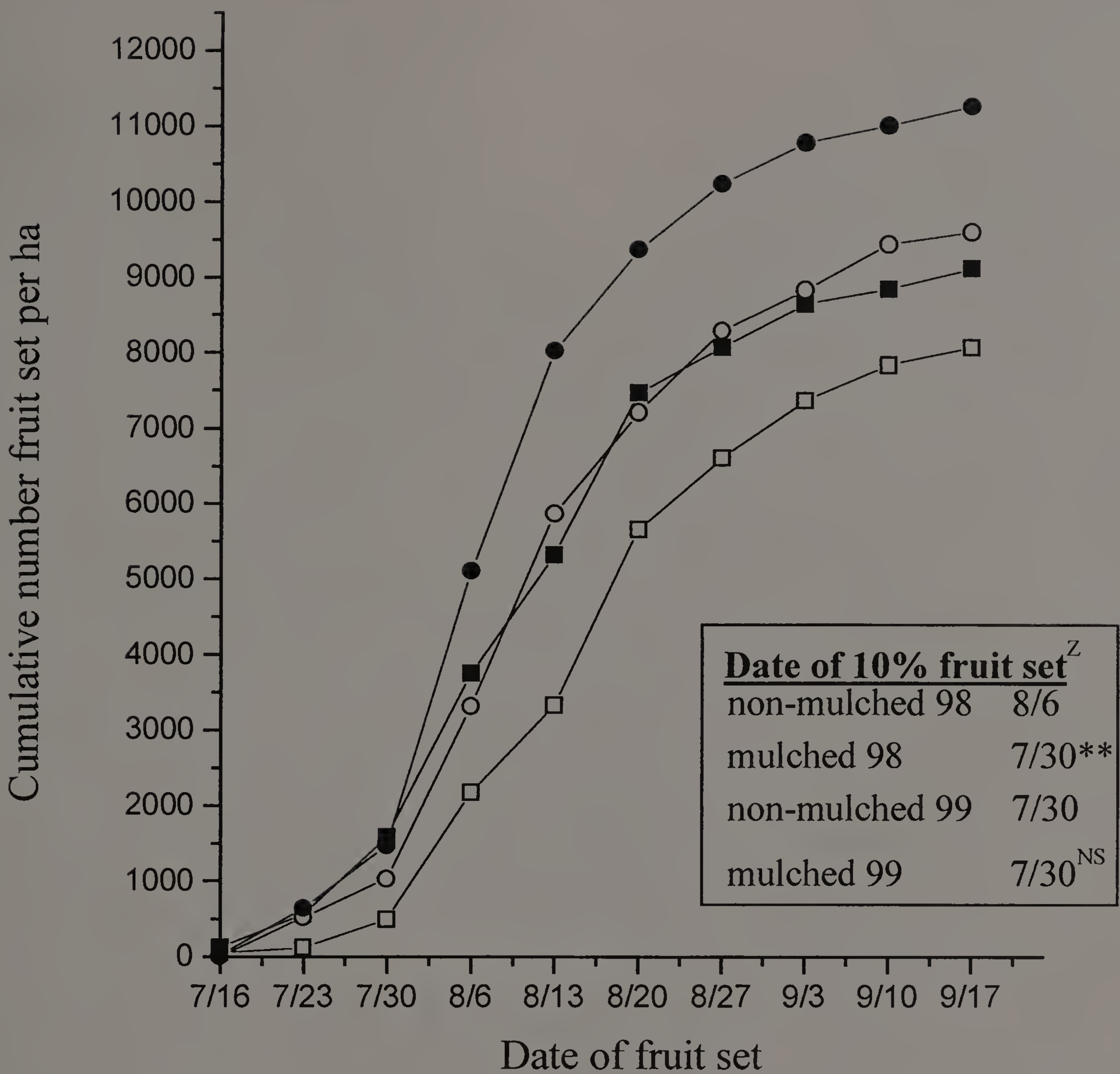

Figure 2.2. Cumulative fruit set as effected by non-mulched or plastic mulched treatments in 1998 and 1999 (□-non-mulched 1998, ■-plastic mulched 1998, ○-non-mulched 1999, ●-plastic mulched 1999).

^{Z} = Date of 10% fruit set is an adjusted average based on all fruit tagged at anthesis by the above dates for the appropriate treatments. ^{NS} = P>0.05, * = P≤0.05, ** = P≤0.01.

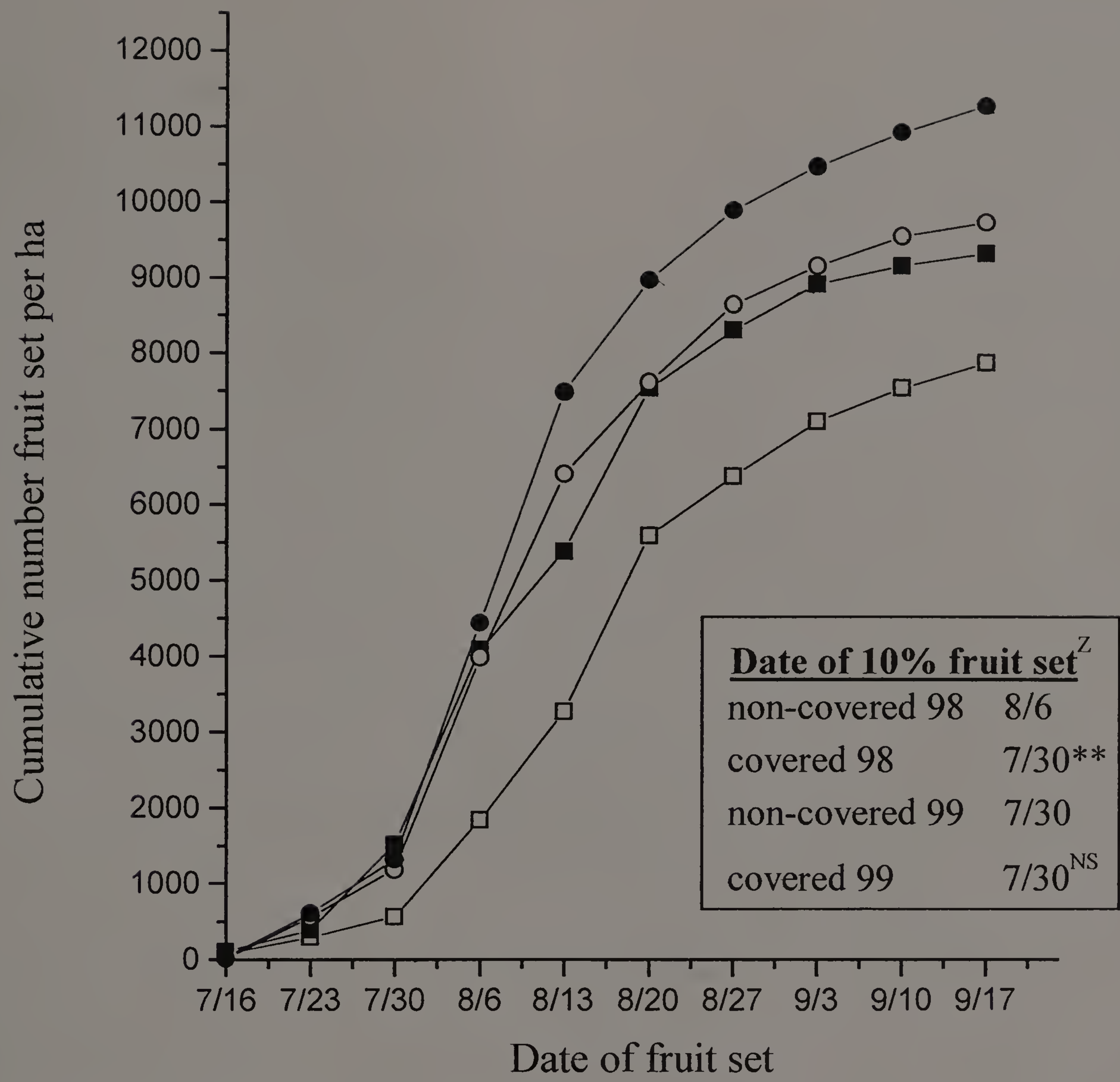

Figure 2.3. Cumulative fruit set as effected by non-covered or polyester spun-bonded row cover treatments for calabaza in 1998 and 1999 (□-non-covered 1998, ■-row covered 1998, ○-non-covered 1999, ●-row covered 1999).

^{Z} = Date of 10% fruit set is an adjusted average based on all fruit tagged at anthesis by the above dates for the appropriate treatments. ^{NS} = P>0.05, * = P≤0.05, ** = P≤0.01.

Table 2.3a. Calabaza and butternut number of fruit per plant, average fruit size, and total yield as effected by the use of transplants, plastic mulch, and row covers in 1998-1999.

	Fruit Yield Characteristics		
Main effects	Avg. # per plant	Avg. fruit wt.(kg)	Total yield ($t \cdot ha^{-1}$)
Direct seeded(TR_0)	4.8	3.3	33
Transplanted(TR_1)	5.9**	3.8**	48**
Non-mulched(PL_0)	4.8	3.5	37
Plastic mulch(PL_1)	5.9**	3.5^{NS}	44**
Non-covered(RC_0)	5.2	3.5	38
Row cover(RC_1)	5.5**	3.6^{NS}	44**

See Table 2.3b for ANOVA

^{NS} = $P>0.05$

* = $P\leq0.05$

** = $P\leq0.01$

Table 2.3b. ANOVA for calabaza and butternut number of fruit per plant, average fruit size, and total yield as effected by the use of transplants, plastic mulch, and row covers in 1998-1999.

	Fruit Yield Characteristics		
ANOVA	Avg. # per plant	Avg. fruit wt.(kg)	Total yield ($t \cdot ha^{-1}$)
Cultivar(C)	**	**	**
Year(Y)	**	**	**
C*Transplant(TR)	-	**	**
TR:Calabaza	-	**	**
TR:Butternut	-	NS	**
C*Row Cover(RC)	-	-	*
RC:Calabaza	-	-	**
RC:Butternut	-	-	*
C*Y	*	**	**
Y:Calabaza	NS	**	**
Y:Butternut	**	NS	**
Y*RC	*	*	*
RC:98	**	*	**
RC:99	NS	NS	**
Y*TR	-	-	**
TR:98	-	-	**
TR:99	-	-	**
Y*Plastic(PL)	-	-	*
PL:98	-	-	*
PL:99	-	-	**
TR*PL	*	-	-
TR:PL_0	**	-	-
TR:PL_1	*	-	-
C*Y*RC	*	*	-
Butternut:RC:98	*	NS	-
Calabaza:RC:99	*	NS	-
Y*PL*RC	-	*	-
1999:RC:PL_1	-	*	-
C*Y*PL*RC[A]	-	**	-
Calabaza:99:RC:PL_0	-	*	-
Calabaza:99:RC:PL_1	-	**	-

‡All other interactions not listed are non-significant

[A] The three-way interaction was analyzed by separating the data for each cultivar and doing f-tests on the two-way interactions.

NS = $P>0.05$

* = $P\leq0.05$

** = $P\leq0.01$

Table 2.4. Calabaza and butternut number of fruit per plant, average fruit size, and total yield as effected by the use of transplants, plastic mulch, and row covers in 1998.

Main effects	Fruit Yield Characteristics: Avg. # per plant	Avg. fruit wt.(kg)	Total yield ($t \cdot ha^{-1}$)
Direct seeded(TR_0)	4.4	3.1	28
Transplanted(TR_1)	5.0*	3.5**	39**
Non-mulched(PL_0)	4.2	3.3	31
Plastic mulch(PL_1)	5.2**	3.2^{NS}	36**
Non-covered(RC_0)	4.4	3.2	29
Row cover(RC_1)	5.0**	3.3*	37**
ANOVA ‡			
Cultivar(C)	**	**	**
C*Transplant(TR)	-	**	**
TR:Calabaza	-	**	**
TR:Butternut	-	NS	**
C*Row cover(RC)	-	-	**
RC:Calabaza	-	-	**
RC:Butternut	-	-	**
C*Plastic(PL)*RC[A]	-	*	-
Calabaza:RC:PL_0	-	NS	-
Calabaza:RC:PL_1	-	*	-
Butternut:RC:PL_0	-	NS	-
Butternut:RC:PL_1	-	NS	-

‡All other interactions not listed are non-significant

[A] The three-way interaction was analyzed by separating the data for each cultivar and doing f-tests on the two-way interactions.

^{NS} = P>0.05

* = P≤0.05

** = P≤0.01

Table 2.5. Calabaza and butternut number of fruit per plant, average fruit size, and total yield as effected by the use of transplants, plastic mulch, and row covers in 1999.

Main effects	Fruit Yield Characteristics: Avg. # per plant	Avg. fruit wt.(kg)	Total yield ($t \cdot ha^{-1}$)
Direct seeded(TR_0)	5.2	3.5	38
Transplanted(TR_1)	6.8*	4.1**	58**
Non-mulched(PL_0)	5.4	3.8	43
Plastic mulch(PL_1)	6.6^{NS}	3.9^{NS}	53**
Non-covered(RC_0)	5.9	3.8	46
Row cover(RC_1)	6.1^{NS}	3.8^{NS}	50*
ANOVA ‡			
Cultivar(C)	**	**	**
C*Transplant(TR)	-	**	**
TR:Calabaza	-	**	**
TR:Butternut	-	NS	*
C*Row Cover(RC)	-	*	-
RC:Calabaza	-	NS	-
RC:Butternut	-	NS	-
Plastic(PL)*RC	-	*	-
$RC:PL_0$	-	NS	-
$RC:PL_1$	-	*	-
C*PL*RC	-	*	-
Calabaza:$RC:PL_0$	-	*	-
Calabaza:$RC:PL_1$	-	**	-
Butternut:$RC:PL_0$	-	NS	-
Butternut:$RC:PL_1$	-	NS	-

‡All other interactions not listed are non-significant

NS = $P>0.05$

* = $P\leq0.05$

** = $P\leq0.01$

Table 2.6. Calabaza number of fruit per plant, average fruit size, and total yield as effected by the use of transplants, plastic mulch, and row covers in 1998-1999.

	Fruit Yield Characteristics		
Main effects	Avg. # per plant	Avg. fruit wt.(kg)	Total yield ($t \cdot ha^{-1}$)
Direct seeded(TR_0)	3.4	5.0	41
Transplanted(TR_1)	4.3**	5.8**	64**
Non-mulched(PL_0)	3.6	5.4	48
Plastic mulch(PL_1)	4.1^{NS}	5.5^{NS}	57**
Non-covered(RC_0)	3.7	5.4	48
Row cover(RC_1)	4.0*	5.5^{NS}	57**
Overall means	4.0	5.5	53
ANOVA ‡			
Year(Y)	**	**	**
Y*Transplant(TR)	**	-	**
TR:98	*	-	**
TR:99	**	-	**
Y*Row cover(RC)	-	*	-
RC:98	-	*	-
RC:99	-	NS	-
Y*PL*RC	*	**	-
98:RC:PL_0	NS	NS	-
98:RC:PL_1	NS	NS	-
99:RC:PL_0	NS	*	-
99:RC:PL_1	*	**	-

‡All other interactions not listed are non-significant

NS = P>0.05

* = $P \le 0.05$

** = $P \le 0.01$

Table 2.7. Butternut number of fruit per plant, average fruit size, and total yield as effected by the use of transplants, plastic mulch, and row covers in 1998-1999.

	Fruit Yield Characteristics		
Main effects	Avg. # per plant	Avg. fruit wt.(kg)	Total yield ($t \cdot ha^{-1}$)
Direct seeded(TR_0)	6.1	1.6	25
Transplanted(TR_1)	7.6**	1.7**	33**
Non-mulched(PL_0)	6.1	1.6	25
Plastic mulch(PL_1)	7.6**	1.6^{NS}	32**
Non-covered(RC_0)	6.7	1.6	27
Row cover(RC_1)	7.0*	1.6^{NS}	31**
Overall means	7.0	1.6	29
ANOVA ‡			
Year(Y)	**	*	**
Y*Row Cover(RC)	**	-	-
RC:98	*	-	-
RC:99	NS	-	-
Y*Transplant(TR)	-	-	*
TR:98	-	-	*
TR:99	-	-	**

‡All other interactions not listed are non-significant

^{NS} = P>0.05

* = P≤0.05

** = P≤0.01

Table 2.8. Butternut number of fruit per plant, average fruit size, and total yield as effected by the use of transplants, plastic mulch, and row covers in 1998.

	Fruit Yield Characteristics		
Main effects	Avg. # per plant	Avg. fruit wt.(kg)	Total yield ($t \cdot ha^{-1}$)
Direct seeded(TR_0)	5.4	1.5	21
Transplanted(TR_1)	6.3^{NS}	1.6^{NS}	26**
Non-mulched(PL_0)	5.3	1.6	22
Plastic mulch(PL_1)	6.4^{NS}	1.5^{NS}	26^{NS}
Non-covered(RC_0)	5.4	1.6	21
Row cover(RC_1)	6.3*	1.6^{NS}	26**

‡All other sources of variation not listed are non-significant

^{NS} = $P>0.05$

* = $P \leq 0.05$

** = $P \leq 0.01$

Table 2.9. Butternut number of fruit per plant, average fruit size, and total yield as effected by the use of transplants, plastic mulch, and row covers in 1999.

	Fruit Yield Characteristics		
Main effects	Avg. # per plant	Avg. fruit wt.(kg)	Total yield ($t \cdot ha^{-1}$)
Direct seeded(TR_0)	6.8	1.6	28
Transplanted(TR_1)	8.9^{NS}	1.8*	40*
Non-mulched(PL_0)	6.9	1.7	29
Plastic mulch(PL_1)	8.8*	1.7^{NS}	39**
Non-covered(RC_0)	7.9	1.7	33
Row cover(RC_1)	7.8^{NS}	1.7^{NS}	35^{NS}

‡All other sources of variation not listed are non-significant

^{NS} = $P>0.05$

* = $P\leq0.05$

** = $P\leq0.01$

Table 2.10. Calabaza number of fruit per plant, average fruit size, and total yield as effected by the use of transplants, plastic mulch, and row covers in 1998.

	Fruit Yield Characteristics		
Main effects	Avg. # per plant	Avg. fruit wt.(kg)	Total yield ($t \cdot ha^{-1}$)
Direct seeded(TR_0)	3.3	4.6	34
Transplanted(TR_1)	3.8**	5.3**	52**
Non-mulched(PL_0)	3.2	4.9	40
Plastic mulch(PL_1)	3.9^{NS}	4.9^{NS}	46*
Non-covered(RC_0)	3.4	4.8	38
Row cover(RC_1)	3.6^{NS}	5.1^{NS}	48**

‡All other sources of variation not listed are non-significant

^{NS} = $P>0.05$

* = $P\leq0.05$

** = $P\leq0.01$

Table 2.11. Calabaza number of fruit per plant, average fruit size, and total yield as effected by the use of transplants, plastic mulch, and row covers in 1999.

	Fruit Yield Characteristics		
Main effects	Avg. # per plant	Avg. fruit wt.(kg)	Total yield ($t \cdot ha^{-1}$)
Direct seeded(TR_0)	3.6	5.5	48
Transplanted(TR_1)	4.8**	6.4**	76**
Non-mulched(PL_0)	3.9	5.9	56
Plastic mulch(PL_1)	4.4^{NS}	6.0^{NS}	68*
Non-covered(RC_0)	3.9	6.0	59
Row cover(RC_1)	4.4*	5.9^{NS}	65^{NS}
ANOVA ‡			
Plastic(PL)*Row Cover(RC)	-	**	-
$RC:PL_0$	-	*	-
$RC:PL_1$	-	**	-

‡All other interactions not listed are non-significant
^{NS} = P>0.05
* = P≤0.05
** = P≤0.01

CHAPTER 3

CONCLUSION

For each treatment main effect; transplants, plastic mulch, and row cover, there were associated production observations of importance. Transplants require greenhouse space and an appropriate method for "hardening off", where they will be protected from rodents. Transplants benefit from being "watered in" and may be impractical for some growers. Row covers provided very succulent growth of the plants but also benefitted the weed population under the covers. In this research, covers were removed regularly to examine plants for striped cucumber beetles (*Diabrotica vittata*) as part of concurrent research, and presented opportunities to mechanically weed plots that were non-mulched. Growers using row covers without plastic mulch should have a weed control strategy in place to protect the plants from competition of resources. Plastic mulch presented removal and disposal issues, as well as the need for specialized equipment.

Calabaza and butternut (*Cucurbita moschata* Duchesne cultivars) are both tropical or sub-tropical in origin but respond differently to growing conditions in Massachusetts. Butternut is an industry standard cultivar which has been bred specifically for cool-climate production. Calabaza, generally, is far more variable in its production qualities and has never been researched for production in cool-climate regions like Massachusetts. Uniformity of physiological traits and crop yield, however, have been improved through breeding research at the University of Florida Gulf Coast Research and Extension Education Center, for a few calabaza selections. Research at the University of Massachusetts Agronomy Farm in South Deerfield was conducted to evaluate 'C42 ×La

Segunda' calabaza for production attributes in a USDA zone 5 climate in comparison to 'Waltham' butternut squash. Calabaza exceeded production expectations and should be considered as a viable crop option for vegetable growers in Massachusetts.

Although consumer preferences for calabaza traits, among Massachusetts Latinos, have not been investigated, production data related to Caribbean Latino preferences provide for an adequate measure. According to Florida calabaza breeder goals, fruit size preferences among Caribbean Latinos fall between 3.6 and 6.8 kg per fruit. Most Caribbean Latino consumers prefer a cut fruit to a whole fruit, as do Massachusetts Latinos (F.X. Mangan, personal communication). Production goals in Florida have targeted 60% of all harvested fruit to fall within the aforementioned size range (D.N. Maynard, personal communication). 'C42 ×LaSegunda' calabaza consistently met this goal in both research years in Massachusetts (Appendix Tables A.10, A.11, and A.12). Total yields also surpassed the targeted 39.2 $t \cdot ha^{-1}$ targeted by Florida producers in both years on average (Table 2.6).

Massachusetts growers who participated in calabaza production trials in 1998 and 1999 reported great feedback regarding product quality and availability (A.K.Carter, personal communication). Growers generally received about \$0.55 to \$0.77 per kg for calabaza sold at regional farmer's markets. Wholesale prices in September at the Chelsea Terminal Market near Boston, Massachusetts are approximately \$0.37 per kg. Conservative yield projections (40 $t \cdot ha^{-1}$) with these prices can provide for a \$22,000 to \$30,800 per ha gross return for direct market producers or \$14,800 per ha for the wholesale market suppliers. By December the price generally increases for wholesale distribution and, provided that storage quality continues to be adequate (A.K.Carter, personal communication), growers could sell calabaza from September through the winter and receive competitive returns when compared to the array of vegetable crops currently produced in Massachusetts.

APPENDIX

TABLES
AND
FIGURES

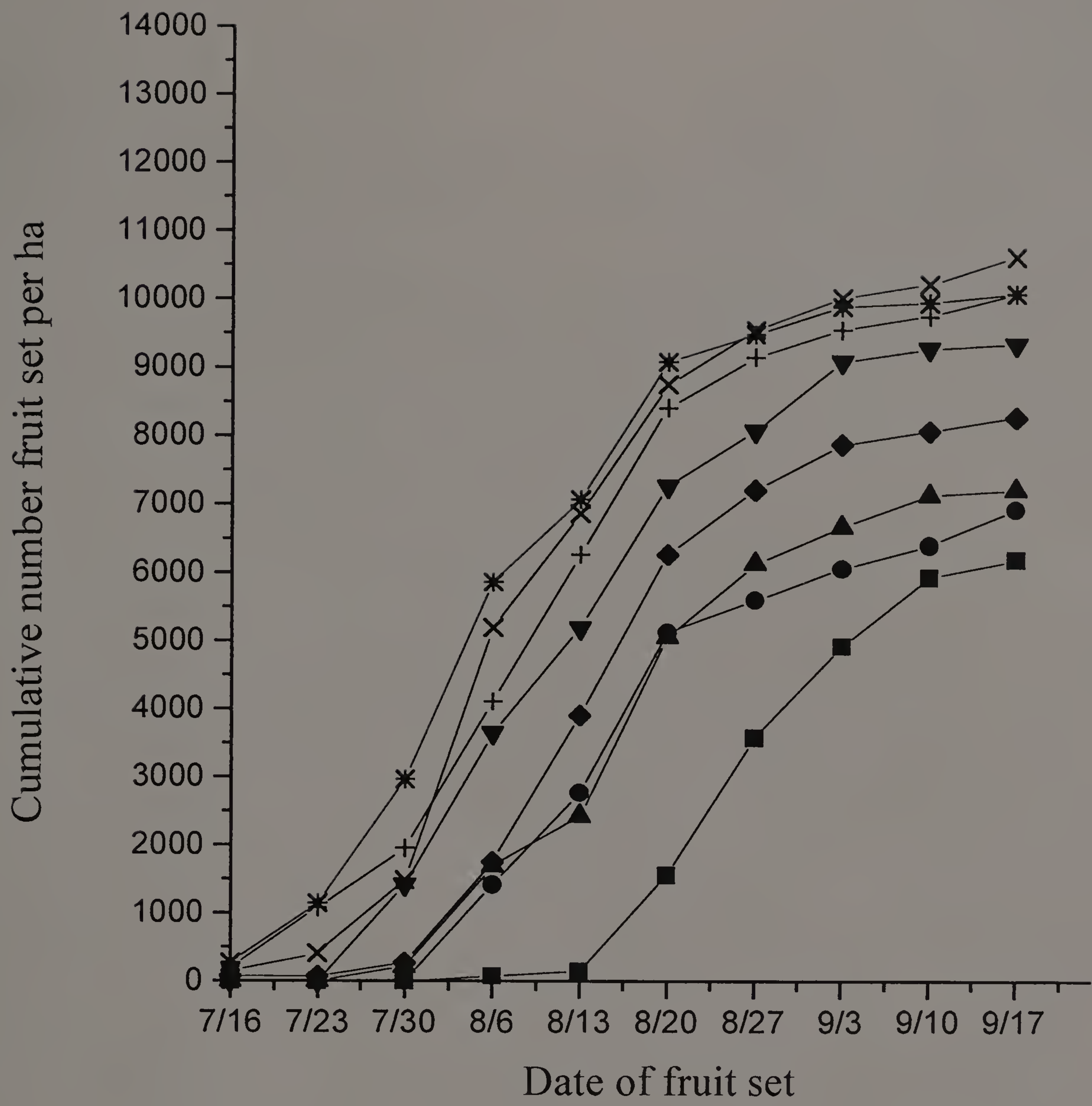

Figure A.1. Cumulative fruit set by treatment combination in 1998 (■-direct-seed/non-mulched/non-covered, ●-direct-seed/mulched/non-covered, ▲-direct-seed/non-mulched/row cover, ▼-direct-seed/mulched/row cover, ◆-transplant/non-mulched/non-covered, +-transplant/mulched/non-covered, ×-transplant/non-mulched/row cover, *-transplant/mulched/row cover).

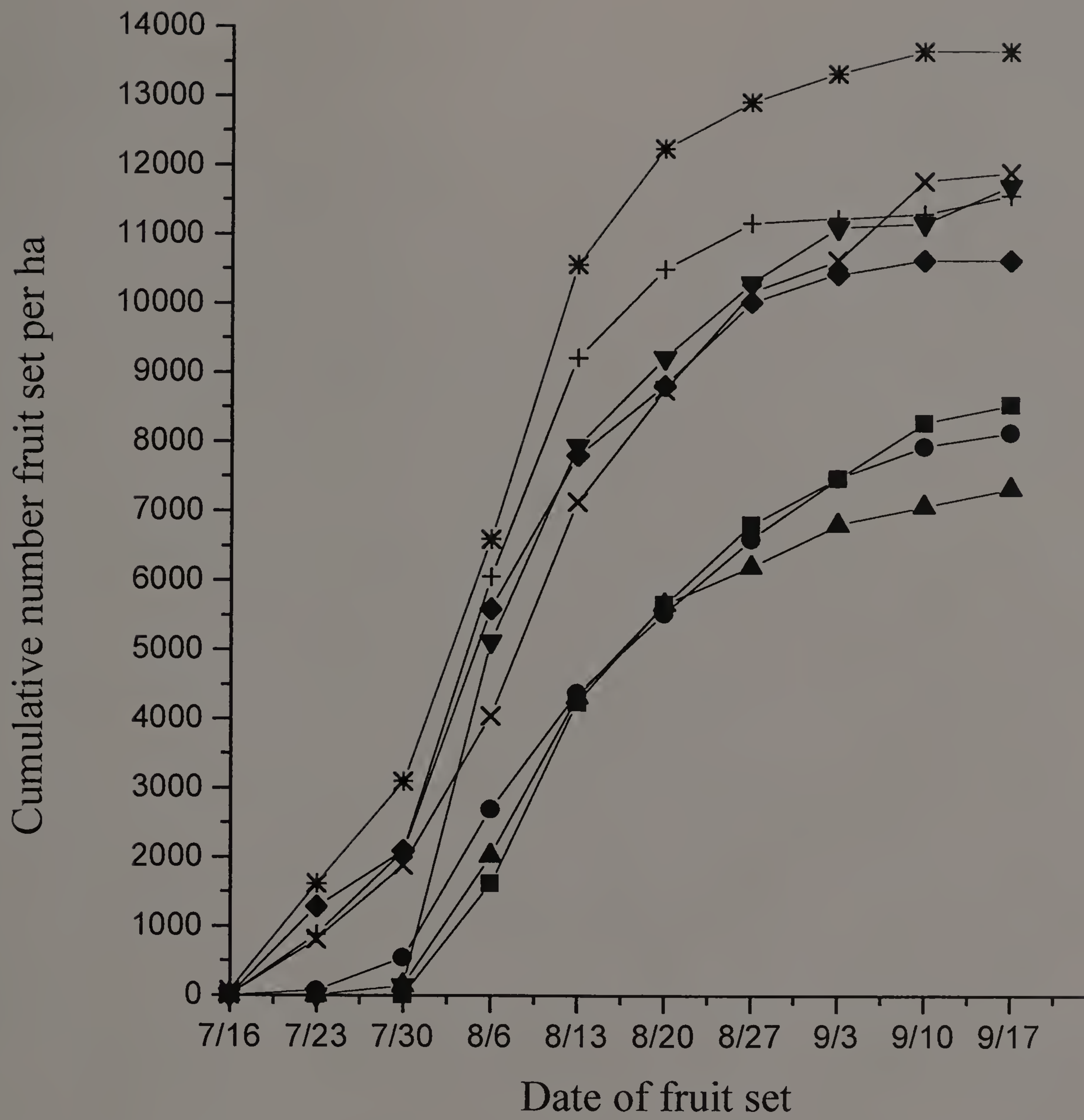

Figure A.2. Cumulative fruit set by treatment combination 1999 (■-direct-seed/non-mulched/non-covered, ●-direct-seed/mulched/non-covered, ▲-direct-seed/non-mulched/row cover, ▼-direct-seed/mulched/row cover, ◆-transplant/non-mulched/non-covered, +-transplant/mulched/non-covered, ×-transplant/non-mulched/row cover, *-transplant/mulched/row cover).

Table A.1. Calabaza fruit set weekly progression by treatment main effect, 1998.

Week		TR_0	TR_1		PL_0	PL_1		RC_0	RC_1
1		0	168		51	118		67	101
2		0	673		118	555		286	387
3		404	1665		488	1581		555	1514
4		1699	4222		2170	3751		1833	4087
5		2624	6021		3330	5315		3263	5382
6		4996	8124		5652	7468		5584	7535
7		5836	8847		6610	8073		6375	8309
8		6677	9335		7367	8645		7098	8914
9		7182	9503		7838	8847		7535	9150
10		7417	9772		8073	9116		7871	9318

KEY:

TR_0-direct-seeded PL_0-non-mulched RC_0-non-covered
TR_1-transplanted PL_1-plastic mulch RC_1-row cover

Table A.2. Calabaza fruit set weekly progression by treatment main effect, 1999.

Week		TR_0	TR_1		PL_0	PL_1		RC_0	RC_1
1		0	17		0	17		0	17
2		17	1144		521	639		555	606
3		202	2288		1026	1464		1178	1312
4		2859	5567		3314	5113		3986	4440
5		5214	8679		5870	8023		6408	7485
6		6509	10075		7215	9368		7619	8965
7		7468	11067		8292	10243		8645	9890
8		8208	11404		8830	10781		9150	10462
9		8612	11841		9436	11017		9537	10916
10		8931	11942		9604	11269		9722	11151

KEY:

TR_0-direct-seeded PL_0-non-mulched RC_0-non-covered
TR_1-transplanted PL_1-plastic mulch RC_1-row cover

Table A.3. Calabaza fruit set weekly progression by treatment combination 1998.

Week		TR_0 PL_0 RC_0	TR_0 PL_1 RC_0	TR_0 PL_0 RC_1	TR_0 PL_1 RC_1	TR_1 PL_0 RC_0	TR_1 PL_1 RC_0	TR_1 PL_0 RC_1	TR_1 PL_1 RC_1
1		0	0	0	0	67	202	135	269
2		0	0	0	0	67	1076	404	1144
3		0	0	202	1413	269	1951	1480	2960
4		67	1413	1682	3633	1749	4104	5180	5853
5		135	2758	2422	5180	3902	6257	6862	7064
6		2557	5113	5046	7266	6257	8410	8746	9082
7		3566	5584	6122	8073	7199	9150	9553	9486
8		4911	6055	6660	9082	7871	9553	10024	9890
9		5920	6391	7131	9284	8073	9755	10226	9957
10		6189	6929	7199	9351	8275	10091	10630	10091

KEY:

TR_0-direct-seeded PL_0-non-mulched RC_0-non-covered

TR_1-transplanted PL_1-plastic mulch RC_1-row cover

Table A.4. Calabaza fruit set weekly progression by treatment combination 1999.

Week		TR_0 PL_0 RC_0	TR_0 PL_1 RC_0	TR_0 PL_0 RC_1	TR_0 PL_1 RC_1	TR_1 PL_0 RC_0	TR_1 PL_1 RC_0	TR_1 PL_0 RC_1	TR_1 PL_1 RC_1
1		0	0	0	0	0	0	0	67
2		0	67	0	0	1278	875	807	1615
3		0	538	135	135	2086	2086	1884	3095
4		1615	2691	2018	5113	5584	6055	4037	6593
5		4238	4373	4306	7939	7804	9217	7131	10562
6		5651	5517	5651	9217	8813	10495	8746	12244
7		6795	6593	6189	10293	10024	11168	10159	12917
8		7468	7468	6795	11101	10428	11235	10630	13321
9		8275	7939	7064	11168	10630	11302	11773	13657
10		8544	8140	7333	11706	10630	11572	11908	13657

KEY:

TR_0-direct-seeded PL_0-non-mulched RC_0-non-covered
TR_1-transplanted PL_1-plastic mulch RC_1-row cover

Table A.5. Butternut&Calabaza: Treatment combination effect on number of fruit per plant, fruit size (kg), and total yield ($t \cdot ha^{-1}$) in 1998-1999.

			Yield Information		
Planting method	Mulch	Row cover	Avg.# fruit /plant	Fruit size (kg)	Total yield ($t \cdot ha^{-1}$)
direct seed	no	no	3.9	3.2	27
direct seed	yes	no	5.4	3.2	33
direct seed	no	yes	4.1	3.4	30
direct seed	yes	yes	5.6	3.4	42
transplant	no	no	5.4	3.8	42
transplant	yes	no	6.0	3.8	48
transplant	no	yes	5.8	3.7	48
transplant	yes	yes	6.5	3.8	54

Table A.6. Butternut&Calabaza: Treatment combination effect on number of fruit per plant, fruit size (kg), and total yield ($t \cdot ha^{-1}$) in 1998

			Yield Information		
Planting method	Mulch	Row cover	Avg.# fruit /plant	Fruit size (kg)	Total yield ($t \cdot ha^{-1}$)
direct seed	no	no	3.4	3.1	22
direct seed	yes	no	4.9	2.8	25
direct seed	no	yes	4.3	3.1	28
direct seed	yes	yes	5.0	3.2	35
transplant	no	no	4.1	3.5	32
transplant	yes	no	5.3	3.3	39
transplant	no	yes	5.1	3.4	41
transplant	yes	yes	5.5	3.6	43

Table A.7. Butternut&Calabaza: Treatment combination effect on number of fruit per plant, fruit size (kg), and total yield ($t \cdot ha^{-1}$) in 1999.

			Yield Information		
Planting method	Mulch	Row cover	Avg.# fruit /plant	Fruit size (kg)	Total yield ($t \cdot ha^{-1}$)
direct seed	no	no	4.5	3.3	32
direct seed	yes	no	5.9	3.7	41
direct seed	no	yes	4.0	3.7	32
direct seed	yes	yes	6.3	3.5	48
transplant	no	no	6.6	4.1	52
transplant	yes	no	6.8	4.2	58
transplant	no	yes	6.5	4.0	55
transplant	yes	yes	7.5	4.0	65

Table A.8. Calabaza: Treatment combination effect on number of fruit per plant, fruit size (kg), and total yield ($t \cdot ha^{-1}$) in 1998-1999.

			Yield Information		
Planting method	Mulch	Row cover	Avg.# fruit /plant	Fruit size (kg)	Total yield ($t \cdot ha^{-1}$)
direct seed	no	no	3.1	4.8	36
direct seed	yes	no	3.6	5.0	38
direct seed	no	yes	3.0	5.2	37
direct seed	yes	yes	4.0	5.2	55
transplant	no	no	3.8	5.9	56
transplant	yes	no	4.3	5.9	64
transplant	no	yes	4.4	5.7	64
transplant	yes	yes	4.6	5.9	70

Table A.9. Calabaza: Treatment combination effect on number of fruit per plant, fruit size (kg), and total yield ($t \cdot ha^{-1}$) in 1998.

			Yield Information		
Planting method	Mulch	Row cover	Avg.# fruit /plant	Fruit size (kg)	Total yield ($t \cdot ha^{-1}$)
direct seed	no	no	2.8	4.6	28
direct seed	yes	no	4.0	4.0	28
direct seed	no	yes	3.0	4.6	33
direct seed	yes	yes	3.5	5.1	47
transplant	no	no	3.0	5.4	45
transplant	yes	no	4.0	5.1	51
transplant	no	yes	4.0	5.2	55
transplant	yes	yes	4.0	5.5	56

Table A.10. Calabaza: Treatment combination effect on number of fruit per plant, fruit size (kg), and total yield ($t \cdot ha^{-1}$) in 1999.

			Yield Information		
Planting method	Mulch	Row cover	Avg.# fruit /plant	Fruit size (kg)	Total yield ($t \cdot ha^{-1}$)
direct seed	no	no	3.5	5.0	43
direct seed	yes	no	3.3	5.9	47
direct seed	no	yes	3.0	5.8	41
direct seed	yes	yes	4.5	5.4	62
transplant	no	no	4.5	6.5	68
transplant	yes	no	4.5	6.7	77
transplant	no	yes	4.8	6.2	73
transplant	yes	yes	5.3	6.2	85

Table A.11. Butternut: Treatment combination effect on number of fruit per plant, fruit size (kg), and total yield ($t \cdot ha^{-1}$) in 1998-1999.

			Yield Information		
Planting method	Mulch	Row cover	Avg.# fruit /plant	Fruit size (kg)	Total yield ($t \cdot ha^{-1}$)
direct seed	no	no	4.8	1.6	18
direct seed	yes	no	7.1	1.5	29
direct seed	no	yes	5.3	1.6	23
direct seed	yes	yes	7.3	1.5	29
transplant	no	no	7.0	1.7	28
transplant	yes	no	7.8	1.7	33
transplant	no	yes	7.3	1.7	32
transplant	yes	yes	8.4	1.7	38

Table A.12. Butternut: Treatment combination effect on number of fruit per plant, fruit size (kg), and total yield ($t \cdot ha^{-1}$) in 1998.

			Yield Information		
Planting method	Mulch	Row cover	Avg.# fruit /plant	Fruit size (kg)	Total yield ($t \cdot ha^{-1}$)
direct seed	no	no	4.0	1.6	15
direct seed	yes	no	5.8	1.5	22
direct seed	no	yes	5.5	1.6	23
direct seed	yes	yes	6.5	1.4	23
transplant	no	no	5.3	1.6	20
transplant	yes	no	6.5	1.6	26
transplant	no	yes	6.3	1.7	28
transplant	yes	yes	7.0	1.7	31

Table A.13. Butternut: Treatment combination effect on number of fruit per plant, fruit size (kg), and total yield ($t \cdot ha^{-1}$) in 1999.

			Yield Information		
Planting method	Mulch	Row cover	Avg.# fruit /plant	Fruit size (kg)	Total yield ($t \cdot ha^{-1}$)
direct seed	no	no	5.5	1.6	21
direct seed	yes	no	8.5	1.6	35
direct seed	no	yes	5.0	1.7	23
direct seed	yes	yes	8.0	1.6	34
transplant	no	no	8.8	1.7	36
transplant	yes	no	9.0	1.8	40
transplant	no	yes	8.3	1.7	37
transplant	yes	yes	9.8	1.8	46

Table A.14. Treatment combination effect on percentage of calabaza fruit that fall into the Caribbean Latino consumer preferred range in 1998-1999.

Planting method	Plastic mulch	Row cover	Consumer Preference (3.6-6.8kg)
direct seed	no	no	54%
direct seed	yes	no	65%
direct seed	no	yes	57%
direct seed	yes	yes	61%
transplant	no	no	51%
transplant	yes	no	54%
transplant	no	yes	58%
transplant	yes	yes	64%
ANOVA ‡			
PL			*
TR x RC			**
Y x PL			*

‡All other sources of variation not listed are non-significant

NS = $P>0.05$

* = $P\leq0.05$

** = $P\leq0.01$

Table A.15. Treatment combination effect on percentage of calabaza fruit that fall into the Caribbean Latino consumer preferred range in 1998.

Planting method	Plastic mulch	Row cover	Consumer Preference (3.6-6.8kg)
direct seed	no	no	50%
direct seed	yes	no	63%
direct seed	no	yes	55%
direct seed	yes	yes	71%
transplant	no	no	52%
transplant	yes	no	55%
transplant	no	yes	59%
transplant	yes	yes	70%
ANOVA ‡			
PL			**

‡All other sources of variation not listed are non-significant
NS = $P>0.05$
* = $P\leq 0.05$
** = $P\leq 0.01$

Table A.16. Treatment combination effect on percentage of calabaza fruit that fall into the Caribbean Latino consumer preferred range in 1999.

Planting method	Plastic mulch	Row cover	Consumer Preference (3.6-6.8kg)
direct seed	no	no	59%
direct seed	yes	no	66%
direct seed	no	yes	59%
direct seed	yes	yes	51%
transplant	no	no	51%
transplant	yes	no	54%
transplant	no	yes	58%
transplant	yes	yes	58%
ANOVA ‡			
TR x RC			**
PL x RC			*

‡All other sources of variation not listed are non-significant

NS = $P>0.05$

* = $P\leq0.05$

** = $P\leq0.01$

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